

NPP IN-SITU GROUND SYSTEM - BRIDGING TECHNOLOGIES BETWEEN EOS, NPP AND THE FUTURE

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ABSTRACT

As part of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), the Direct Readout Laboratory (DRL) of NASA/GSFC Code 935, is developing the prototype NPP In-Situ Ground System (NISGS). The NISGS supports earth remote sensing, and its functions bridge from all EOS satellites to planning for future NASA and interagency launches. The NISGS solution enables the end user to acquire and process NPP and predecessor instrument data, and provide a means to make these technologies and data products available to the Direct Broadcast Community. This document describes the NISGS model, methodology, and system architecture.

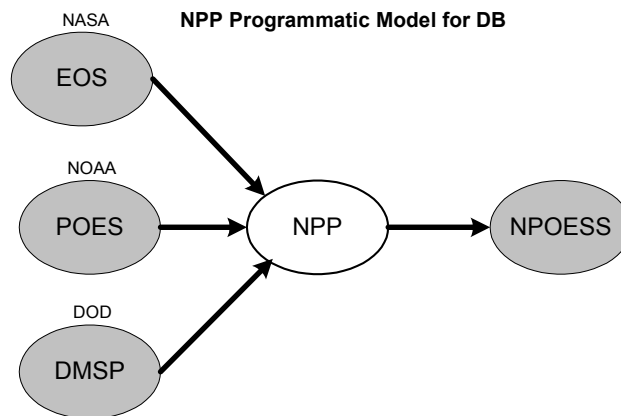
KEY WORDS

Direct Broadcast, Direct Readout, Direct Broadcast Community, NISGS Model, NISGS Technologies

INTRODUCTION

Over the last 30 years there has been a rapid increase in the number of remote sensing satellites that support environmental monitoring. These have evolved to have greater complexity and an increased number of sensors, resulting in increased data bandwidth and data volume. This increase in capability and enhancements has placed a significant burden on the user community. The community must keep up with the evolving spacecraft communication system and instrument specifications, and it must handle the exponentially increasing data volume and complex data processing algorithms required to make the data useful.

Under the NPP, NASA is developing the NPP In-Situ Ground System (NISGS) , to provide a Direct Broadcast (DB) solution that incorporates instruments from the Earth Observing System (EOS), Polar Orbiting Environmental Satellites (POES), and Defense Meteorological Satellite Program (DMSP) and provides the foundation for, and path to, the future NPOESS satellites. The NISGS solution will be available at no cost to the DB community through a software public-release program.



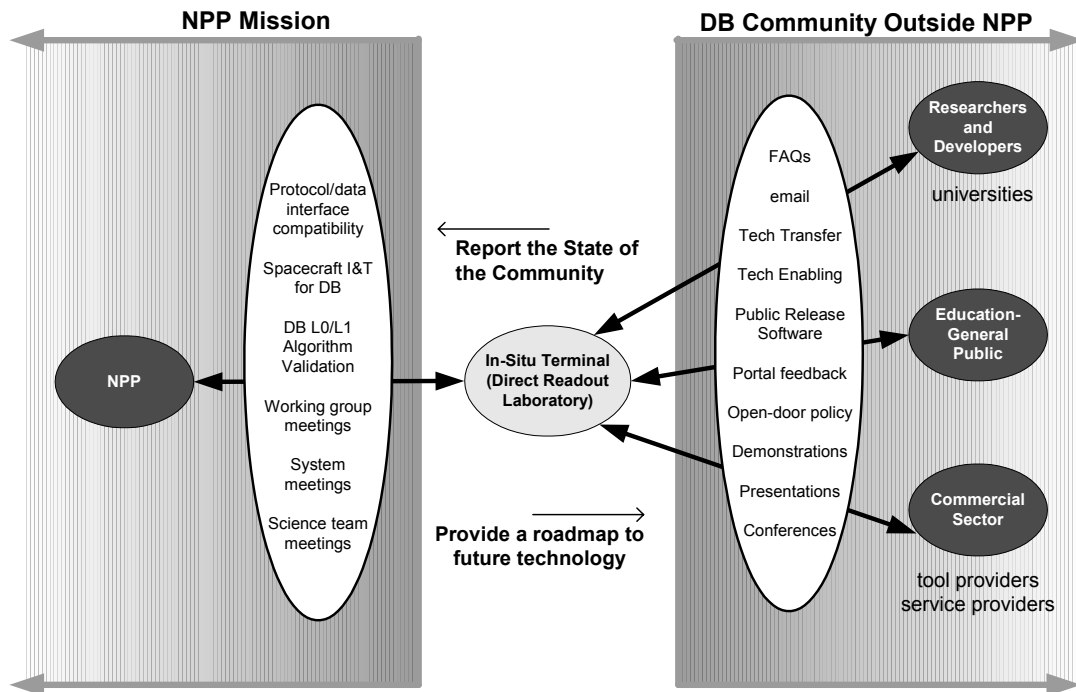
The goal of NISGS is to enable and develop technology that benefits the entire DB community. The DB community is defined as any person or group that uses, benefits from, or contributes to the acquisition of remotely sensed direct broadcast data. The community ranges from the commercial sector that provides processing components to the scientist that evaluates the most recent data acquisition results. Other members of the community include but are not limited to academia, forest service personnel, fire fighters, meteorologists, general public, Department of Defense (DOD), Integrated Program Office (IPO), researchers, algorithm developers, and NASA. The DB community currently has over 2000-fielded POES and EOS systems worldwide.

NISGS is comprised of integrated DB technologies in order to provide a complete direct readout ground system solution. The NISGS technologies include the Real-Time Software Telemetry Processing System (RT-STPS); the Multi-Mission Scheduler (MMS); the NPP Earth Science Technology Office (ESTO) Portal for Science, Technology and Environmental Research (NEpster); Simulcast; and Direct Broadcast/Institutional science processing algorithms. RT-STPS performs Consultative Committee for Space Data Systems (CCSDS) protocol processing and Level-0 formatting. MMS performs scheduling and control of the ground system elements. Simulcast distributes quick look instrument data to internet-based clients in real-time. NEpster serves as a virtually connected network of data archive systems providing access to direct broadcast data to anyone with a web browser. The science processing algorithms process Level 0 data to geolocated, calibrated radiances, from which a number of geophysical value-added products can be generated. Each of these technologies function stand-alone and can be easily implemented into any in-situ ground terminal.

The NISGS technologies target most of the necessary steps prior to value added image product generation. They also incorporate all instrument and spacecraft-specific formatting, encoding and configurations, thereby alleviating the end-user of this resource consuming task.

DRL ROLE IN THE NPP IN-SITU ELEMENT

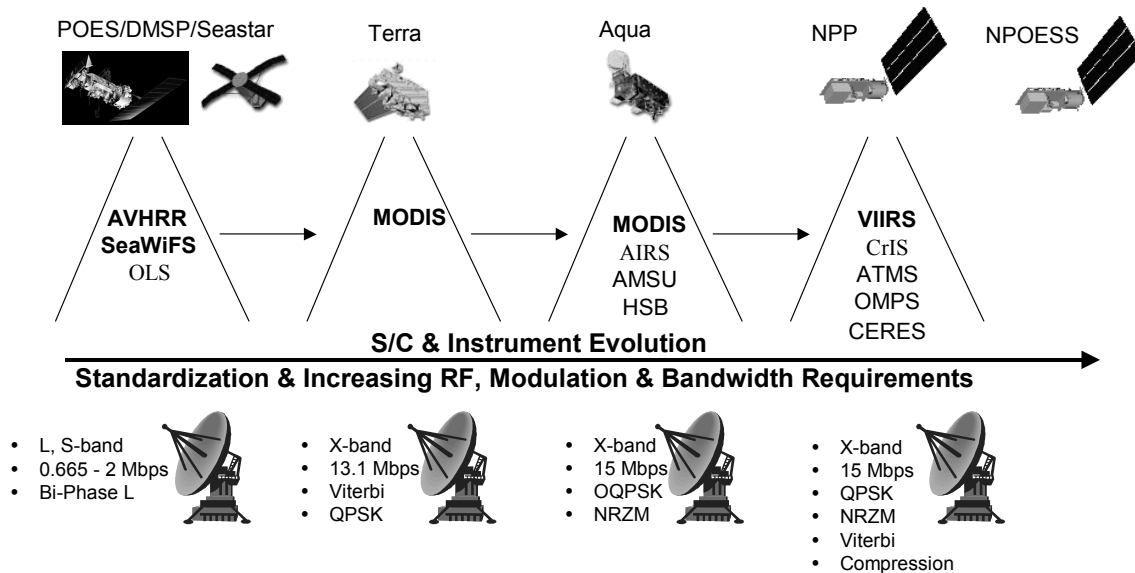
The Direct Readout Lab (DRL) plays a vital role in the DB community as intermediary between NPP and the “non-NPP” community. The DRL encourages communication and maintains an open-door policy with the commercial and Research and Development (R&D) sectors. This process provides the DRL with critical information such as what equipment is currently in use, what technology is being developed commercially, and what the needs of the community outside NPP are. As a result, the DRL can report the “state of the community” to NPP while simultaneously providing the community outside NPP a roadmap to future NPP technology.



NISGS inherits the DRL's knowledge, experience and lessons learned from prior missions, which brings continuity from the EOS mission to NPP, and subsequently, to NPOESS. With its experience, the DRL can predict problem areas in the design and development of NISGS and mitigate them before problems develop.

The following roadmap shows the DRL history of involvement and the path to the NISGS solution, and highlights many of the features, differences, and similarities between missions.

DRL Roadmap to NPP and Beyond



NISGS MODEL

It should be recognized that the NISGS Model is a system architecture and a methodology. In this methodology, the DB community is the driving force for DB service-type requirements, which often translates to system design requirements. The goal is to make every NISGS product and function a reflection of the community voice and the community needs within the scope of the NPP mission.

An essential component of the NISGS model is the technology transfer and technology sharing methodology. The NISGS model is focused on ultimately becoming a conduit for technology and information sharing for the DB community. As a conduit for DB data, technology, and information, NISGS becomes the central point for the community sectors to share and obtain information. NISGS provides a central communication point, which ultimately results in greater accessibility of information and technologies to the DB community.

An important feature of the NISGS model is that the commercial sector is recognized as part of the DB community. As such, the commercial sector is included in system design decisions and kept in the "information loop." This gives the commercial sector the option to develop and design solutions that meet upcoming and established DB requirements.

The goals of the NISGS model can be summarized as follows:

- 1) **Provide prototype NISGS** to satisfy the NPP mission requirements while incorporating the philosophies of other NISGS model goals. The system architecture and technologies will be made available to the DB community at no cost.
- 2) **Reflect DB community voice** that defines requirements and future development plans. The DB community voice is multi-faceted because the community is comprehensive. Therefore, to truly reflect the community, all the different sectors

must be canvassed and information congealed into an encompassing repository of facts.

- 3) **Incorporate lessons learned** to promote the development of a realistic development timeline. The advantages of using knowledge gained through practical experience are vast. Using lessons learned advances development without past mistakes being repeated, without redesigning existing components, and with less error as the process is based on established methodologies.

With its history of close involvement with the Terra and Aqua missions, the DRL is the common thread from those missions to NISGS. This maintains continuity and ensures that knowledge is not lost between missions.

- 4) **Enable technology to support DB** by both providing an infrastructure to develop technology and enabling the evolution of technology. The goal of technology enabling is accomplished as a two-part concept.

The first part of enabling technology is to provide the technology. This is a literal scheme, for which technology transfer is the primary method. This means that the NISGS develops and verifies the technology to acquire and process remotely sensed earth science data, and then provides the technologies at no cost to the DB community.

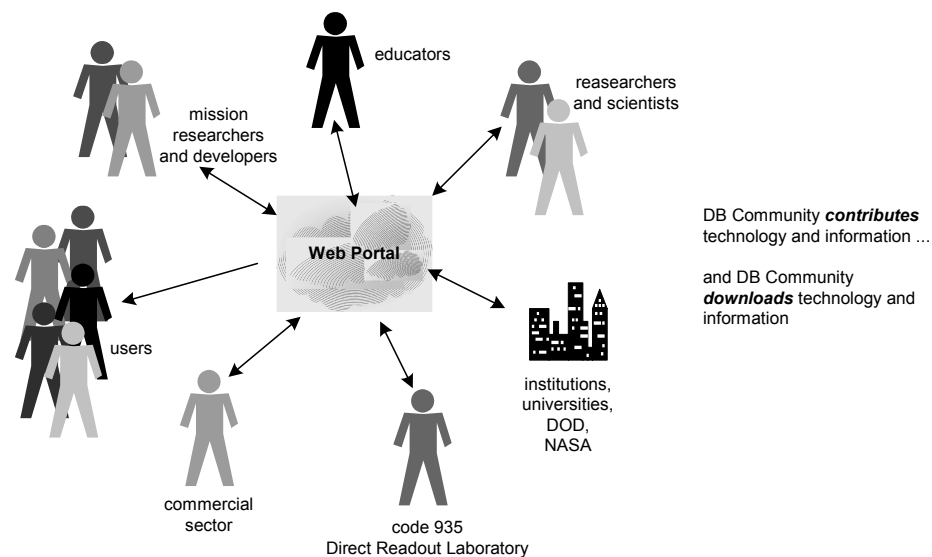
The second part of enabling technology is to enable the commercial sector, or any other interested DB community member, to develop solutions that will meet future mission needs. To do this, the DRL provides mission requirements and defines where technologies should be heading to meet community needs.

- 5) **Develop technology to support specific needs of DB for NPP by providing** technologies that process instrument data end-to-end, to provide a multi-mission solution, and to provide re-configurable technologies for the acquisition and processing of remotely sensed earth science data.

Technology development has two different paths in the NISGS model: 1) NISGS enables commercial development, which is then made available to the DB community. For this path, NISGS provides Non Recurring Engineering (NRE) to a vendor with the understanding that the developed technology can be redistributed; 2) The DRL, under the NISGS Model, develops technology that meets custom mission requirements.

- 6) **Share technology and information via the NISGS Model**, which disseminates technology, data, and information, and encourages feedback. The medium created to achieve this objective is the Direct Readout Web Portal located at: <http://directreadout.gsfc.nasa.gov/>

Provide Web Portal for Technology and Information Sharing



Another primary goal for the NISGS is that it manages and provides access to a global DB near real-time data repository. The level-0 data is kept indefinitely and higher-level products are available on-line for 30 days. The data repository provides a web-based interface that allows users to select data by region. The repository must accept global DB data input from subscribers.

- 7) **Provide outreach**, by making the community aware of the types of technology and information that comprise a Direct Readout System. The goal is to provide a bridge from the scientific community to the general public, focusing on the interface with the educational sector.

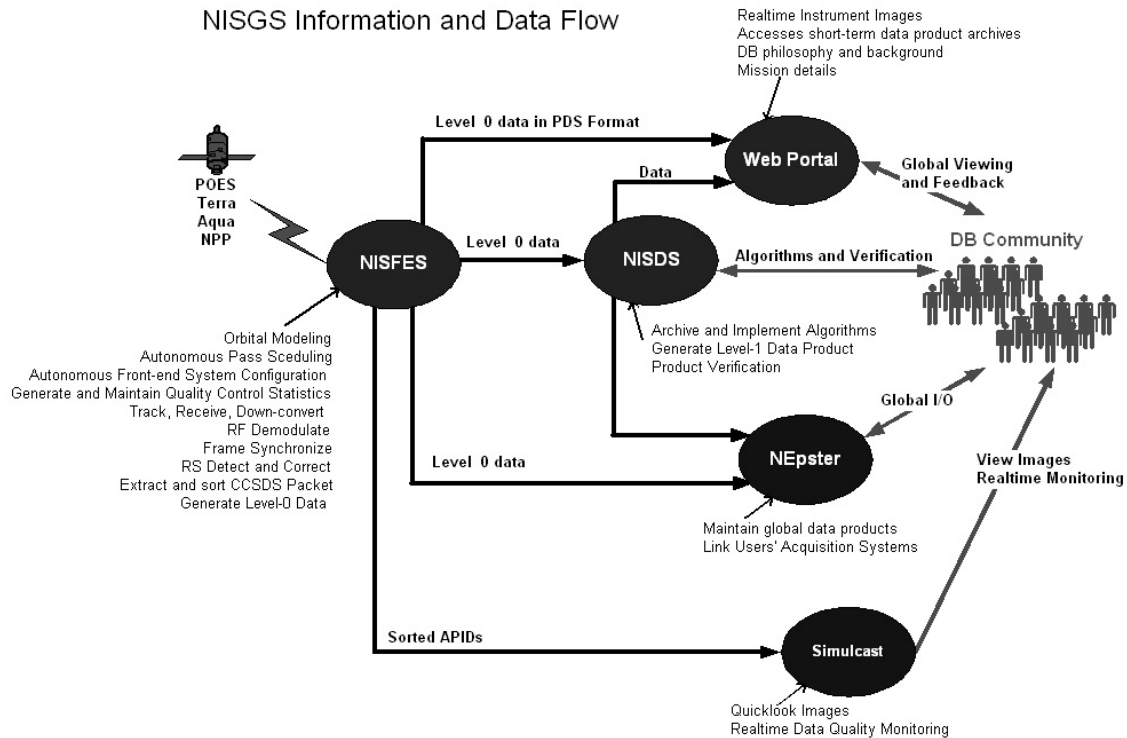
NISGS ARCHITECTURE

The NISGS accepts a satellite downlink and provides information and data products to the DB Community. The processing between input and output is complex and is best defined by grouping elements into subsystems that can then be further dissected and explained.

The NISGS Architecture is separated into the following functional subsystems:

- 1) **NISGS Front-End System (NISFES)** provides orbital modeling and autonomous pass scheduling, decodes data, performs all CCSDS protocol processing, and outputs level zero data products for archival. It also outputs filtered instrument packets to a socket, which will be used by another subsystem (Simulcast) for quick look images that provide real-time data quality monitoring via the Internet.
- 2) **NISGS Data System (NISDS)** autonomously accepts level-0 data products, generates level one data, and uses level-2 algorithms for data verification. All data products are archived.

- 3) **Web Portal** provides technology, information, and data sharing with the DB community.
- 4) **Simulcast** provides quick look instrument images broadcasted over the Internet.
- 5) **NEpster** provides a single access point that represents a virtually connected network of DB receiving stations to provide global access for DB data for data management and distribution.



NISGS SUBSYSTEMS

MMS

The Multi-Mission Scheduler (MMS) provides NISGS automation. The MMS is a configurable, client-server processing element that automates ground system data acquisition, data processing, and data distribution. The future JAVA implementation of MMS will include a documented Application Programming Interface (API) so that it can be easily integrated into any ground system environment.

A MMS client resides on each piece of equipment to be controlled. The scheduler, within MMS server, serves as the central point for control of all software and hardware subsystems. Scheduler communicates with each client via a User Datagram Protocol (UDP) socket, and uses data and events as feedback to dynamically control data acquisition and processing. The client configures, starts and stops software tasks local to the device on which it is installed.

Scheduler is configured by a Graphical User Interface (GUI), which allows the operator to completely configure and control MMS.

RT-STPS

RT-STPS provides the NISFES Protocol Processing and Level-0 Data Production. RT-STPS is designed as a collection of independent processing nodes. This is so a user can create standard or custom pipelines by plugging together selected nodes using XML setup scripts. It does not require any special hardware or native library support. Therefore, it runs on any system where Java is installed, yet it runs as fast as C and C++ equivalents. RT-STPS ingests satellite data, performs complete CCSDS protocol processing, and then provides level-0 data distribution to end-users. RT-STPS has two modes of operation. In stand-alone batch mode, the source is a local file. In server mode, RT-STPS runs continuously and waits for raw data input to arrive at a TCP/IP or UDP socket. RT-STPS can send processed data units to a file or directly to a network destination via TCP/IP sockets.

The primary job of RT-STPS is to synchronize CCSDS version 2 telemetry frames (CADUs) and to compose independent CCSDS packet streams, which are distinguished by spacecraft (SCID), virtual channel (VCID), and application (ApID). To support the DB community, it also includes a node that creates EOS-compliant PDS level-0 files. However, RT-STPS can also receive and identify non-CCSDS frames, and it provides additional CCSDS services to those previously listed. Other RT-STPS features include a rate-buffering client, which regulates transmissions for unpredictable or slower network connections, and a graphical viewer, to ease configuration and observe processing status. RT-STPS processing has been successfully verified with live Terra MODIS data and with live Aqua data. The most CPU intensive RT-STPS processing, which includes Reed-Solomon decoding, has been bench marked at rates in excess of 20 Mbps.

SIMULCAST

Simulcast is the NISGS Real-Time Data Quality Monitoring Subsystem. Simulcast generates quick look real-time images to provide data quality monitoring during a satellite pass. Simulcast has been verified with live Terra and Aqua MODIS instrument data, and the redesign in Java will include multiple instruments of the NPP.

Simulcast is a client-server subsystem that is designed to allow a client connected anywhere on the Internet to display a real-time instrument image. The Simulcast server receives CCSDS packet data from the ground system, decodes the packets and processes and sends reduced volume images to connected clients. The Simulcast remote clients display the imagery and other data statistics in real-time during the satellite pass.

Simulcast works without modification of front-end hardware since the interface is either socket or file-based. It is useful for monitoring and for troubleshooting both ground systems and spacecraft systems. The client-server design allows for remote monitoring from virtually anywhere via the Internet.

ALGORITHMS

The NISGS system incorporates instrument algorithms, which would be required as a pre-processing step to value added, Level-2, product generation. These steps primarily consist of calibration and geo-registration. Historically, these algorithms, considered "Institutional", have been embedded in a large, interdependent system that process global data. Therefore, by definition, they will not run in a standalone, or direct broadcast mode without environment variable changes, ancillary data sets, math libraries and prior

processing steps. Consequently, it has been incumbent upon the user to make the necessary changes and environment set-ups to run these algorithms; delaying use of NASA's data by the DB community by as much as two years after launch.

Based on these lessons learned, the NISGS concept preempts this scenario by working with the Level-1 algorithms during their conception, in an attempt to create standalone, DB algorithms that would be available prior to launch. Additionally, select Level-2 algorithms would be ported for the purpose of validating the end-to-end NISGS system. This will be done by comparing the resultant physical parameters with the "Institutional" global data products generated by the Science Data Segment (SDS).

The current algorithm test-bed used in the formulation of the NISGS data system is the Terra/Aqua Direct Readout System that provides level-1 processing, archives the data products, and then makes the level-1 and select level-2 data products available to the DB community.

The test instrument algorithm used in this test-bed is the MODIS Level-1 processing software which is a set of science processing algorithms that produce geolocated, calibrated radiance from raw Level 0 production data sets. It includes:

- The Level-1A algorithm, which reorganizes the raw data;
- The geolocation algorithm which geolocates each MODIS field of view; and
- The calibrated radiance (Level-1B) algorithm, which outputs calibrated radiance at 1 KM, 0.5 KM and 0.25 KM resolutions.

Similar processes and procedures will be undertaken for the NPP's VIIRS, CrIS, ATMS, OMPS and CERES instruments. Therefore, the implementation approach undertaken by the NISGS team is to work with the instrument calibration and georegistration algorithm developers to bring these algorithms into NISGS as a stand alone, but integral part of the end-to-end processing of all NPP instrument data.

NEpster

The NEpster System serves as a virtually connected network of data archive systems providing access to DB data to anyone who has access to the Internet. This model is based on a peer-to-peer architecture of sharing and exchanging remote sensing data among end users. The architecture borrows the idea from a well-known system known as Napster, where music files are shared and exchanged among the end users across the Internet. In NEpster, this type of functionality is emulated, but several additional features have been added to handle the uniqueness of remote sensing data and its sources. The principle features include: a temporary data storage area for remote sites that do not wish their servers accessed on a continual basis, an intelligent broker that controls data access based on the data distribution policies of each independent data source, and a comprehensive geographically-based query interface to allow efficient data searches.

The system works as follows: A DB community member initiates a request via the NEpster Operator Interface (NOI). The query request from NOI is sent to a database, which contains metadata information on the data set registered with the server. Based on the metadata, a database server sends the query results back to the user via the NOI. The results contain metadata information, data file sizes, and policy information on the availability and the location of the requested data. At this point, the user has the option to initiate an ftp session or URL request to the data repository site.

SUMMARY

The NISGS solution is a multi-mission, multi-instrument ground system that will insure integrity, reliability, and easy access to NPP and EOS mission data. NISGS creates a bridge from legacy to future missions so that capabilities are not lost and technology is not reinvented. The design and implementation of NISGS will follow the DRL methodology that includes the DB community in each phase, and ensures technology and information is shared as the DRL acts as a conduit between NPP and the other sectors of the DB community.

The DRL insures the success of NISGS by the implementation of the credible and successful approach used to provide Terra and Aqua DB ground system support. Information will flow bi-directionally through the DRL to insure communication between sectors of the DB community and the NPP. The numerous satellites require standardization in communication and data format protocols. The DRL will maintain an approach that encourages consistency and standardization. As the DB community grows, making changes on the DB satellite will become more dramatic and have further reaching effects, increasing the need of standardization and consistency from satellite to satellite. The DRL is also prepared for any non-standard features or changes that must be implemented, by either enabling or developing the technology to accommodate the changes. The methodology and foresighted approach used by the DRL insures that the NISGS will remain a successful and vital part of the DB community.

ACKNOWLEDGEMENTS

This research is being funded by the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP).

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